Report on the Development of an Automated Fish Sorting System Using Machine Vision

Kevin McCarthy

Fisheries Development Division
Fisheries and Habitat Management
Newfoundland Region
P.O. Box 5667
St. John's, Newfoundland
A1C 5X1

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March 1988

DEVELOPMENT OF AN AUTOMATED FISH SORTING SYSTEM USING MACHINE VISION

By

Kevin McCarthy[1]

For

Fisheries Development Division

Fisheries and Habitat Management

Newfoundland Region

P.O. Box 5667

St. John's, Newfoundland

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[1] Kevin McCarthy, Grove Telecommunications Ltd., St. John's, Newfoundland.

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ABSTRACT

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A prototype Fish Monitoring System (FMS-1000) was developed during 1984-86. It was installed in a fish processing plant and tested in a commercial production environment. The system included a conveyor belt, a light table and a system of pneumatically controlled chutes or gates used to route different species/sizes of fish onto appropriate filletting lines. Fish were routed from the plant holding room to the filletting lines via the FMS 1000; passing over the light table each was photographed by a video camera positioned over, identified by contour outline, assigned a length/weight category, and routed onto a filletting line. The chuting system and the computer software were modified during testing so that eventually the FMS 1000 was able to adequately supply properly size-sorted fish to a filletting line system having a peak (day-shift) production rate of 125,000 lb. in an eighthour period. The system was used primarily on cod; because the plant was in full production 16 hours a day it was very difficult to complete tests of the accuracy of the vision process in species recognition. Recommendations for further improvements to the system were developed and the FMS 1000 was removed from the plant to undergo modification.

PREFACE

The development of the FMS-1000 to its present level was sponsored by the Department of Fisheries and Oceans, St. John's, Newfoundland, under DFO/DSS Contracts.

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The National Research Council also provided a research grant.

All measurements used in this report are imperial measurements which is the system used by the fish processing industry in Eastern Canada, including National Sea Products' plant in Arnold's Cove, Newfoundland, where the field trials took place.

Scientific Authority:

Gerald Brothers
Technical Development Officer
Department of Fisheries and Oceans
P.O. Box 5667
St. John's, Newfoundland
A1C 5X1

INTRODUCTION

This report marks the completion of the second phase of a fish data collection system study conducted by Grove Telecommunications Ltd. and partially financed by the Canadian Government. The sponsor for the project was the Department of Fisheries and Oceans, St. John's, Newfoundland, Canada.

Machine Vision enables a computer to interpret visual data using a system of pattern matching. The demonstration system was capable of determining the length, species and weight of a series of fish passing under the camera and producing a printed output of the results (Fig. 3). This output could be transmitted to a distant terminal via a modem interface.

After consultation with representatives of the fishing industry concerning the usefulness and direction of the concept, it became evident that one of the primary uses of the FMS-1000 would be the sorting of fish in a land-based, in-plant environment. National Sea Products Ltd. was very interested in the FMS-1000 for this purpose and provided the use of its processing plant in Arnold's Cove, Newfoundland to further develop and test the system in a working plant environment.

PROTOTYPE DEVELOPMENT

PHASE I

During Phase I it was proposed that a data collection system be developed for trawlers at sea (Fig. 1). This system was designed to collect

vessel, catch, environmental and positional data and transmit it to shore to form a real-time management database. The vessel and positional data was readily available via existing off-the-shelf systems. However, it soon became apparent that an automatic fish monitoring system would have to be developed. In September of 1984, Phase I of the Fish Monitoring System began, and, with the assistance of C & W Welding Ltd. of Bay Bulls, Newfoundland, (fabricators of the light table) a demonstration system was constructed (Fig. 2). The system consisted of a video camera, image processor, keypad, programming terminal, monitor, printer and custom light table. During development, Grove Telecommunications Ltd. received considerable assistance through a technology transfer from an American firm specializing in machine vision systems.

PHASE II

Phase II of the project focused on the development of the prototype plant version of the FMS-1000 which included a fish handling mechanism to properly align the fish for presentation to the machine vision system as well as software refinements to support these handling methods. In the latter part of 1985, Grove hired two software personnel and enrolled them in a Machine Vision training program which included specialized training in the programming languages and software use by the FMS demonstration system.

A development team from Grove travelled to National Sea Products' Plant at Arnold's Cove to examine the plant's existing processing system. Grove then contracted C & W Welding Ltd. to fabricate a table (Fig. 4) designed to carry the fish on a conveyor belt over a backlit area where an

outline of the fish would be recorded by the image processor (Fig. 5). The table, as shown in Fig. 6, was designed with a belt wide enough to facilitate parallel lanes of fish, with a six position chute system for each lane. The entire table was 12 feet long and 40 inches wide, not including the chute system. The vision belt was 36 inches wide and constructed of an opaque material. The backlit area measured 50 inches by 36 inches and light was provided by 12, 48 inch flourescent tubes. The belt was driven by a variable speed DC drive so that an optimum speed could be determined during testing.

The chute system consisted of solenoids, pneumatic cylinders and pistons and proximity limit switches. Each chute measured 22 inches long by 14 inches wide and was attached to the table by a piano hinge. They were supported below by the pneumatic cylinders and by extending and retracting the pistons the chutes moved up and down. There were two different chutes (Fig. 7) each of which had three different positions for a total of six possible destinations. One chute was mounted at the end of the conveyor belt and the other was mounted on the side of the table for each line of fish. A flipper mounted over the belt guided the fish onto the side chute which, in turn, moved to one of its three positions.

All electrical components (DC drive, solenoids, lighting, etc.) were housed in a completely waterproof enclosure and all electrical connections to the table (with the exception of the camera) were made via one 1" cable.

When fabrication of this unit was complete it was shipped to Grove's development facility in St. John's for further software development which included two major tasks before testing could begin, the creation of new

software for the programmable controller, and modification of the existing vision software to allow the running of two lanes of fish simultaneously.

Software was created for the programmable controller which controlled the movement of the chutes based on the information received from the image processor. This program had to be sufficiently detailed to handle a fast flow of different size fish and yet fast enough to allow it to run accurately at the processing speeds required. Both the vision processor and the programmable controller were fitted with compatible TTL input/output cards which made communication between the two processors fast and simple.

In order to run two lanes of fish simultaneously, numerous modifications to the existing software were necessary as well as the creation of a new interrupt routine. This interrupt routine closely monitors one lane while a fish is being analyzed in the other lane.

The original software required that the fish be presented to the camera head first. It was found that this required more work by the operator and thus, could cause throughput to decrease. Grove modified the software so that fish could be presented to the system head first or tail first. This is an example of how complex the software is which allows more liberal guidelines in the fish handling mechanisms. This type of hardware/software interaction was found to be very important throughout the entire project.

When all these changes had been made, Grove spent considerable time testing and fine tuning the system. It was decided that the most effective way to ensure proper separation between the fish and minimize errors due to improper orientation was to utilize two separate conveyor belts operating

at different speeds. A chain link conveyor was attached to the input end of the FMS table which operated at a slower speed than the belt on the FMS table. This slower belt was referred to as the infeed conveyor while the belt on the FMS table was referred to as the vision conveyor. A clean transition from the infeed conveyor to the vision conveyor resulted in very few errors due to insufficient separation and improper orientation and thus required less complexity in the vision system's boundary determination algorithm.

Since Grove now had a fully operational FMS-1000 at its facility in St. John's, the development team took advantage of this opportunity to test the system using cod as often as possible. The tests proved very valuable for a variety of reasons including the fine tuning of both the vision software and Allen-Bradley software, and to prove the reliability and speed of the chute system components (solenoids and pneumatic pistons). Belt speeds were varied to determine the speeds which minimized presentation errors and at the same time maximized throughout.

Before transporting the system to Arnold's Cove for field trials, tests were carried out to determine the accuracy of the length calculation under laboratory conditions. A random sample of 20 cod fish was measured by the development team to the nearest one quarter of an inch following which the fish were each run through the FMS three times. The length was recorded each time and an average for each fish calculated. The results (Table 1) showed an accuracy rate of 99.5%. It should be mentioned here that the accurate measuring of the length of a fish by either the FSM-1000 or a member of the development team was difficult because of the nature of the tail of the fish. The shape and position of the tail could change each time

the fish is handled and could mean a variation of up to 3mm (1/8 of an inch) either way in the total length of the fish.

Repeatability tests were also conducted at the development facility. Ten fish were selected at random and each was run through the system 10 times. Each length was recorded and the mean and variance calculated. Results of these tests (Table 2) showed an accuracy rate of 99.6% with an average variance of 0.5mm (0.02132 inches).

FIELD TRIALS

When Grove, officials from the Department of Fisheries and Oceans and National Sea Products Ltd. were convinced that the FMS-1000 was ready for field testing in an in-plant environment, the system was installed in a plant in Arnold's Cove. It was connected to the production line with two chute positions feeding directly to the filletting lines and the remaining four to boxes in which the fish were iced and processed at a later time. Since the FMS was installed for testing and development purposes, the disk drive system as well as the CRT and video monitor were included. These components of the system were needed to support a full programming environment so that changes to the software could be made if necessary.

Using the FMS-1000 in an actual production line presented a number of problems.

1. Operators found it impossible to orient the fish for the vision system at the speed they were being taken from the de-icing hopper. The manual culling system was a 'bursty' system meaning that the fish arrived at the FMS in 30-40 second 'bursts'.

2. Bugs existed in the software and periodically the vision processor had to stop analysing the fish and send them all to the same destination.
3. Species identification software was not completely reliable and problems existed in differentiating between cod and pollock and between cod and catfish.

The problem of the bursty feed system was alleviated somewhat by the installation of a foot switch which transferred control of the de-icing hopper belt to the operator. This worked to some degree, but the FMS still could not cope with a full production shift.

As a result of these problems, and the fact that the plant could not revert to its manual culling system with the FMS in place, it was decided to remove the system from the production line and relocate it in a corner of the holding room. With this arrangement, the development team could work on the FMS-1000 without causing any plant production loss.

With the FMS set up in the corner of the holding room, Grove endeavoured to correct the problems encountered while the FMS was in the production line. A great amount of time was spent reviewing the boundary determination algorithms and modifications were eventually made to this portion of the program. The revised software, was tested by running fish under the camera in various different orientations. It soon became evident that the problem causing the program to stop execution had been eliminated and that errors resulting from bad presentation had been greatly reduced.

With this software problem eliminated, the development team concentrated their efforts on increasing throughput and improving species recognition software. The pollock and catfish recognition algorithms were

modified somewhat, but since cod represented 95% of the plant's production, the development team focused their main efforts on increasing throughput, and delayed further software development until returning to St. John's.

In order to increase throughput, belt speeds were varied and time trials were performed with the belts set at different speeds. From these tests, belt speeds were arrived at which the development team believed would allow the FMS to keep up with the plant's throughput rate of 56,700Kg. (124,000 lbs) of cod per eighthour shift.

The FMS-1000 was now put back into the production line. This time the system was installed in such a way that the plant could revert to its manual culling system at any time without loss of production. This allowed Grove to make further minor modifications to the system without interferring with the plant's operation. The FMS worked extremely well on night shift, but still could not supply enough fish to maintain the usual production rate of the day shift. The day shift utilizes three automatic filletting machines, while the night shift utilizes only two, so the night shift production rate is 36,280 Kg (80,000 lbs.) compared with 57,700 Kg. (125,000 lbs) for this day shift. When running the FMS-1000 on night shift, there was no problem keeping well ahead of the shift's production. In fact, many times during a shift the operator had to stop feeding the FMS-1000 and wait for the backup of fish on the filletting lines to be cleared. Although running the FMS on night shift was not a good test for maximum throughput capacity of the machine, it was invaluable for testing the reliability and accuracy of the software. Stations were set up where fish were sampled at random and measured by length. Results were recorded on an FMS-1000 Evaluation Form (Fig. 8) and (Table 3) showed the length

calculation of the FMS to be accurate to 6mm (1/4 inch) at a rate of 99.04%.

Grove developed weight at length formulas based on statistics obtained from National Sea Products Limited and initial testing of these formulas indicate the weight calculation to be 98.58% accurate (Table 4). Since the plant was in full production 16 hours each day, it was difficult for the development team to complete a formal test of the accuracy of the species recognition.

It was noted during night shifts that the floor supervisor must be able to easily adjust the length range parameters and chute positions for the various categories (primarily lengths of fish). The vision processor software was modified so that this could be accomplished via input from a Function Control Keyboard. While running the FMS on night shifts at Arnold's Cove, Grove decided that three things would have to change in order to achieve the desired throughput on the day shift:

1. Belt speeds had to increase;
2. The Allen-Bradley software had to undergo major modifications;
3. A different method of feeding fish to the FMS was needed.

Initially, belt speeds were increased to a speed of 30m (100 ft)/min for the infeed belt and 60m (200ft)/min for the vision belt. It was calculated that these speeds were necessary to put 120, 50cm (20") fish through the system every minute (Table 5). To accommodate this greater flow of fish, the Allen-Bradley software was completely rewritten and modifications were made to the chutes.

With these modifications in place, the chutes could move from the bottom position to the middle position without first having to travel to the top position as was the case previously (Fig. 7). A small catch basin was installed at the beginning of the infeed belt held the fish until an operator moved the fish onto the belt. It was felt that this method, using two operators if necessary, would be much faster and easier than the previous method of having one operator orient the fish as they passed along a moving belt.

When all of these changes were complete, Grove tested the FMS using two operators. Throughput was now increased enough for the FMS-1000 to keep up with the day shift production rate of 56,700 Kg (125,000 lbs) per eight hour shift.

Grove continued to run the FMS on day shifts and night shifts and gave numerous demonstrations to representatives from government as well as the fishing industry. When Grove was satisfied with the performance of the FMS-1000 and were convinced that no further beneficial development could be accomplished in the plant, the system was returned to Grove's development facility in St. John's to undergo some design changes.

RECOMMENDATIONS

A great deal of knowledge was gained from using the FMS-1000 in an actual production line. Based on this -

1. A new chute system be designed utilizing only one-way pneumatic pistons to open or close gates. This would increase throughput and also minimize the distance the fish must fall to reach its destination.

2. A new take-away chute system, perhaps an active system consisting of several conveyor belts, be designed to take the fish from the FMS to the proper place in the plant to permit lowering of the FMS table. The table in Arnold's Cove was installed at a height of approximately 3-4m (10-12 feet) so that the take-away chutes could use gravity flow to carry the fish from the table to the existing filletting lines.
3. An operator's control panel be designed that can be mounted in the holding room near the FMS table. This panel would give the floor supervisor complete control over the system so that he would be able to quickly and easily vary the length and weight range parameters as well as choose which destination a category of fish is to be sent (Fig. 9).
4. Further software development be done in the area of species recognition.
5. A different type of belt be used on the infeed conveyor. In Arnold's Cove a chainlink belt was used which seemed to be a safety hazard.
6. The backlit area of the FMS be enlarged to eliminate the "fuzzy" corners on the video monitor. These "fuzzy" corners caused some problems when defining the boundary of the fish.
7. A fully operational FMS complete with a satellite communication terminal be placed onboard a vessel to test both the operation of the FMS at sea and the extraction of data from the FMS via satellite communications.

Grove has already started to take action on all of these recommendations and are presently having a new system manufactured with these changes in place.

CONCLUSION

With the completion of Phase II of the FMS-1000 project and the successful field trials conducted at National Sea Products' Plant in Arnold's Cove, Grove Telecommunications Ltd. is encouraged by their findings. Grove feels that they have proven the system's ability to sort fish by length or weight, and that with a few modifications, the FMS-1000 is ready to be marketed. Grove is also confident that computer systems such as the one utilized in the FMS-1000, which have the ability to process images in real-time, thus permitting automation of repetitive and sometimes complex human tasks, can find a wide range of applications in the fish processing industry.

ACKNOWLEDGEMENTS

Grove Telecommunications Ltd. would like to acknowledge the support of the management and staff of National Sea Products' plant in Arnold's Cove, Newfoundland, who allowed the field trials of the FMS-1000 to take place in a production environment.

TABLE 1. FMS-1000 CALCULATED LENGTH VS. ACTUAL LENGTH COMPARISION PERFORMED IN GROVE'S DEVELOPMENT FACILITY

FISH #	FMS-LENGTH (inches)	ACTUAL LENGTH	ERROR	%
1	19.3	19 1/2	.05	0.25
2	17.4	17 1/4	.15	0.87
3	21.0	21	.00	0.00
4	28.7	28 3/4	.05	0.17
5	15.1	15	.10	0.67
6	16.7	16 1/2	.20	1.21
7	23.5	23 3/4	.25	1.05
8	26.6	26 1/2	.10	0.38
9	30.8	31	.20	0.65
10	17.6	17 1/2	.10	0.57
11	16.6	16 3/4	.15	0.89
12	15.5	15 1/2	.00	0.00
13	23.1	23	.10	0.43
14	23.9	24	.10	0.42
15	16.0	16	.00	0.00
16	19.6	19 3/4	.15	0.75
17	20.4	10.1/2	.15	0.73
18	14.9	15	.10	0.67
19	19.2	19 1/4	.05	0.26
20	18.5	18 1/2	.00	0.00

AVERAGE ERROR = .10 INCH APPROX 3/32 INCH.

AVERAGE ERROR (%) = .4985%

ACTUAL LENGTH MEASURED BY THE DEVELOPMENT TEAM CAN ONLY BE CONSIDERED ACCURATE TO THE NEAREST 1/4 inch.

FMS-1000 CALCULATES LENGTH TO THE NEAREST 1/10 INCH.

TABLE 2. RESULTS OF REPEATABILITY TESTS PERFORMED IN GROVE'S DEVELOPMENT FACILITY

FISH	MEAN (INCHES)	VARIANCE	AVERAGE ERROR (Deviation from Mean)	%
1	22.97	.0023	.042	0.18
2	17.06	.0049	.056	0.33
3	23.60	.0067	.040	0.17
4	24.14	.0027	.048	0.20
5	23.83	.0112	.090	0.38
6	23.22	.0573	.216	0.93
7	23.34	.0027	.048	0.21
8	25.28	.0084	.080	0.32
9	17.71	.0316	.018	0.11
10	24.61	.0854	.268	1.09
AVERAGE		.02132	.0906	.392

TABLE 3. RESULTS OF FMS-1000 CALCULATED LENGTH VS. ACTUAL LENGTH COMPARISON PERFORMED AT NATIONAL SEA PRODUCTS' PLANT IN ARNOLD'S COVE

RESULTS OF LENGTH ACCURACY TESTS PERFORMED IN ARNOLD'S COVE

TOTAL NUMBER SAMPLED	520
# OF FISH ERROR 1/4 inch	5
ACCURACY RATE (TO WITHIN 1/4 inch)	99.04%

TABLE 4. RESULTS OF FMS-1000 CALCULATED WEIGHT VS. ACTUAL WEIGHT COMPARISON PERFORMED IN GROVE'S DEVELOPMENT FACILITY USING FORMULAS DERIVED FROM DATA OBTAINED FROM NATIONAL SEA PRODUCTS LTD.

LENGTH	CALCULATED WEIGHT	ACTUAL WEIGHT	ERROR	PERCENT ERROR
16.00	1.527	1.486	0.041	2.746
16.50	1.627	1.562	0.065	4.128
17.00	1.733	1.704	0.030	1.743
17.50	1.847	1.846	0.000	0.016
18.00	1.967	1.985	0.018	0.886
18.50	1.096	2.128	0.032	1.513
19.00	2.233	2.274	0.041	1.792
20.00	2.637	2.600	0.036	1.398
20.50	2.809	2.789	0.020	0.730
21.00	2.993	2.984	0.008	0.280
21.50	3.188	3.204	0.015	0.478
22.00	3.397	3.456	0.059	1.713
22.50	3.619	3.636	0.017	0.473
23.00	3.855	3.875	0.020	0.518
23.50	4.107	4.158	0.051	1.236
24.00	4.375	4.391	0.016	0.360
24.50	4.661	4.676	0.014	0.302
25.00	4.966	4.938	0.028	0.571
25.50	5.291	5.191	0.100	1.926
26.00	5.636	5.431	0.206	3.785
26.50	6.005	5.889	0.116	1.963
27.00	6.088	6.251	0.163	2.601
27.50	6.486	6.512	0.026	0.401
28.00	6.910	6.810	0.100	1.463
28.50	7.362	7.299	0.063	0.858
29.00	7.843	7.889	0.047	0.592
29.50	8.355	8.028	0.328	4.081
30.00	8.901	8.810	0.091	1.036
30.50	9.483	9.587	0.104	1.084

AVERAGE ERROR: .063 Lbs (1.10 oz) 1.42%

ACTUAL WEIGHT IS AN AVERAGE WEIGHT OF ALL SAMPLES IN A PARTICULAR LENGTH RANGE

TABLE 5. CALCULATION OF REQUIRED BELT SPEEDS

Desired Throughput: (100% efficiency)	*since National Sea Products Ltd., Arnold's Cove, used a "Bursty" system meaning that the fish arrived at the FMS-1000 in 30-40 seconds Bursts, it was necessary to calculate the required belt speed much higher than the maximum shift production.
	150,000 Lbs/8 hours.
	= 18,750 Lbs/hr = 312.5 Lbs/min = 120 Fish/min
	(based on 20" Fish, average 2.6 lbs/fish).
Required Belt Speed:	= 120 fish/min 2 lanes = 60 fish/min per lane = 1200 inches/min (20 inch fish) = 100 ft/min

TABLE 6. TIME TABLE OF EVENTS

October 1984	Work began on the demonstration system (Phase I)
October 1985	Acceptance of Phase I
November 1985	Work began on the design of the inplant version of the FMS-1000 (Phase II)
February 1986	Fabrication of the FMS-1000 began at C & W Welding's facility in Bay Bulls, NF
April 1986	Fabrication of the FMS-1000 was completed and it was moved to Grove's development facility.
June 1986	The FMS-1000 was moved to National Sea Products' plant in Arnold's Cove, Nfld. for inplant testing. It was installed in a vacant portion of the holding room.
August 1986	The FMS-1000 was installed in the Production Line at the Arnold's Cove Plant.
October 1986	The FMS-1000 was removed from the plant and returned to Grove's development facility.

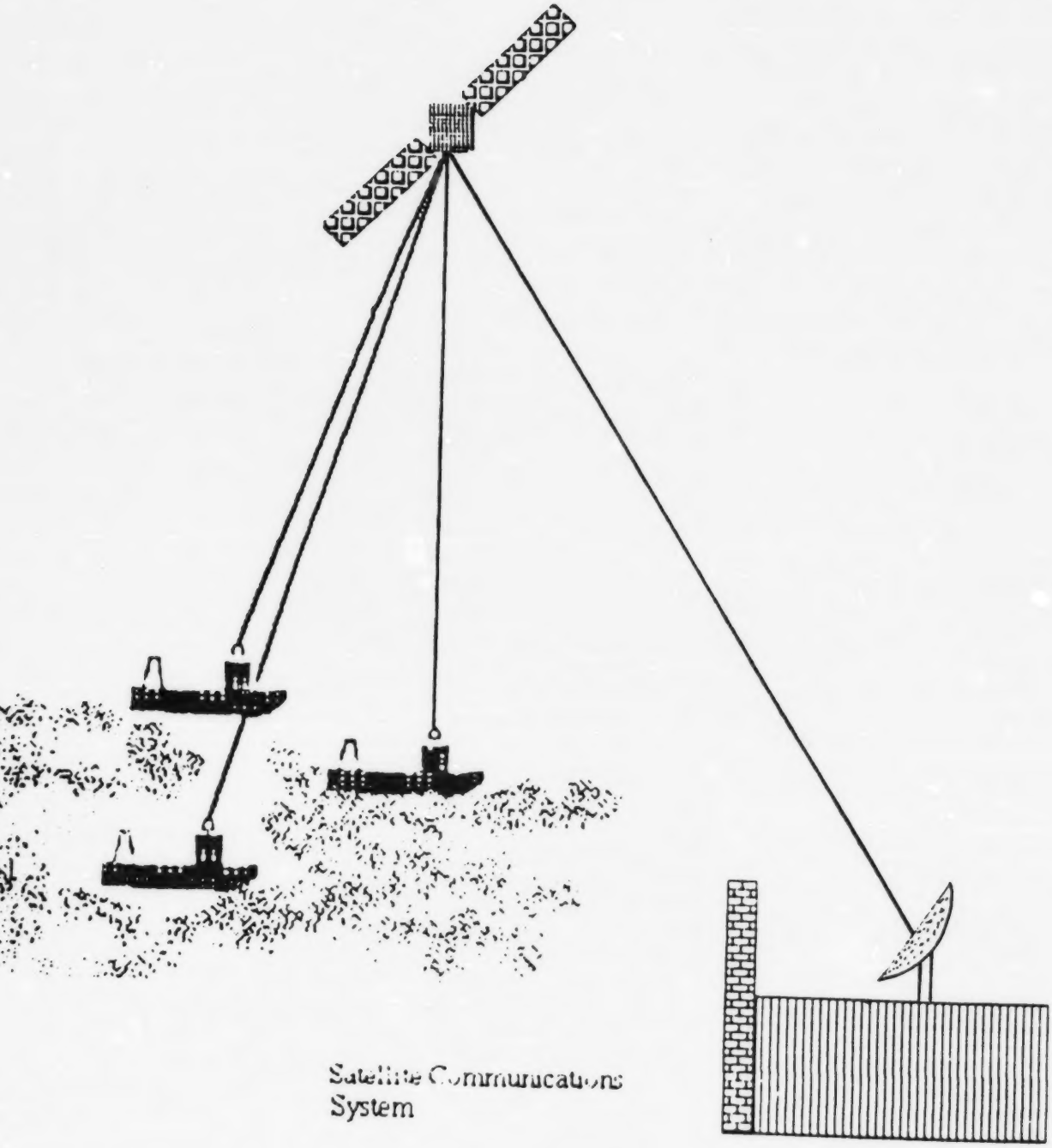


Fig. 1. Satellite Communications System

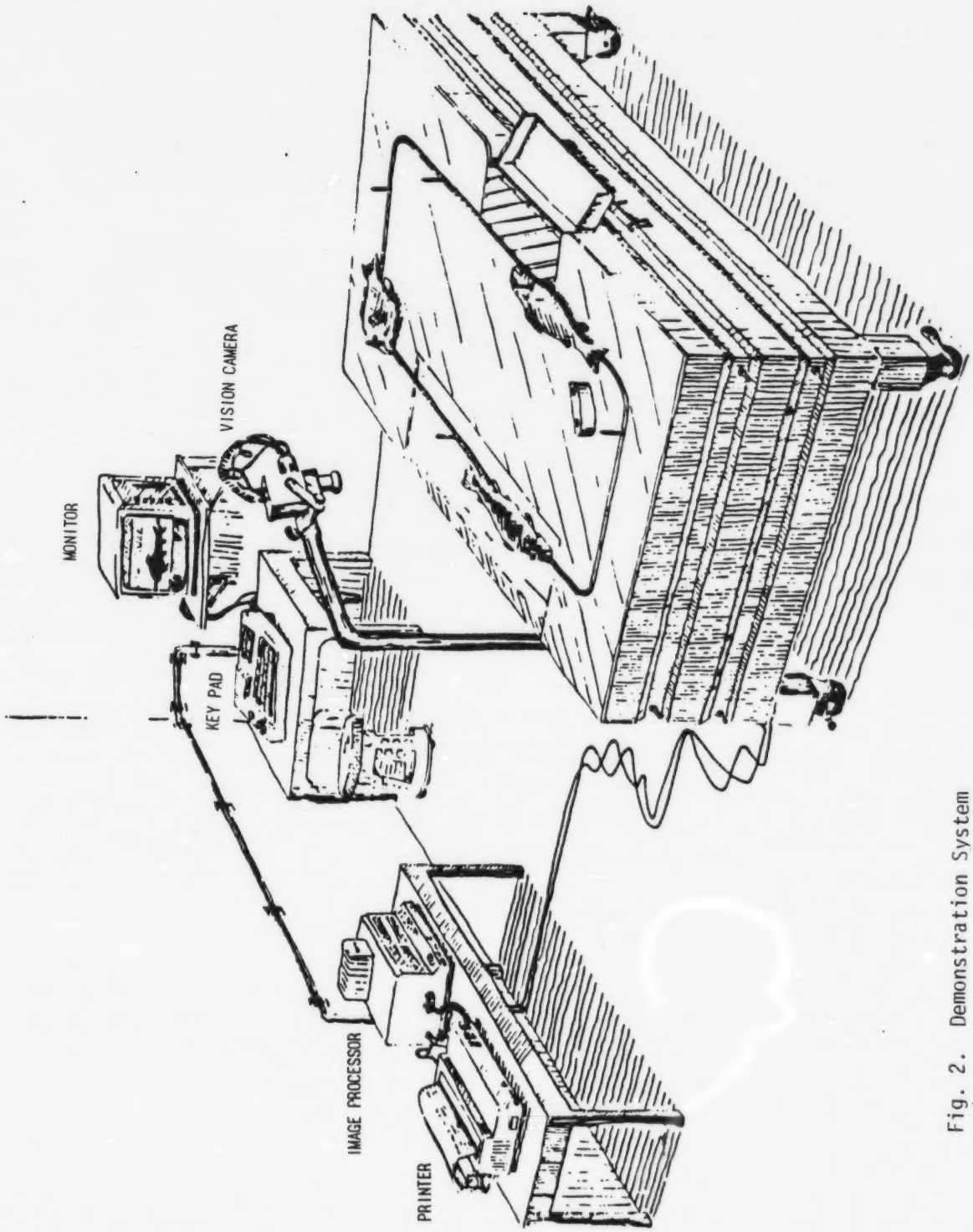


Fig. 2. Demonstration System

21-Aug-87

MATRIX OF FISH LENGTHS BY SPECIES CLASS

Total Weight = 120497.5 lbs.

Class	Length Range (inches): under 20	20-25	25-28	over 28	Total Number	Total Weight
COD	1472	21112	14	0	22598	91900.1
POL/HAD	0	2287	0	0	2287	12836.8
TURBOT	0	0	0	0	0	0.0
FLOUNDER	0	0	0	0	0	0.0
REDFISH	0	0	0	0	0	0.0
CATFISH	1453	247	2665	0	4365	15763.7
'OTHER'	0	0	0	0	0	0.0
Total Number	2925	23646	2679	0	29250	
Total Weight	4950.1	102991.0	12558.4	0.0		120497.5

Note: 0 fish were not oriented properly.

Weight of cod under 20 inches = 2776.9 lbs.

Weight of cod 20 - 25 inches = 89055.0 lbs.

Weight of cod 25 - 28 inches = 68.4 lbs.

Weight of cod over 28 inches = 0.0 lbs.

Fig. 3. Hard Copy Output From the FMS-1000

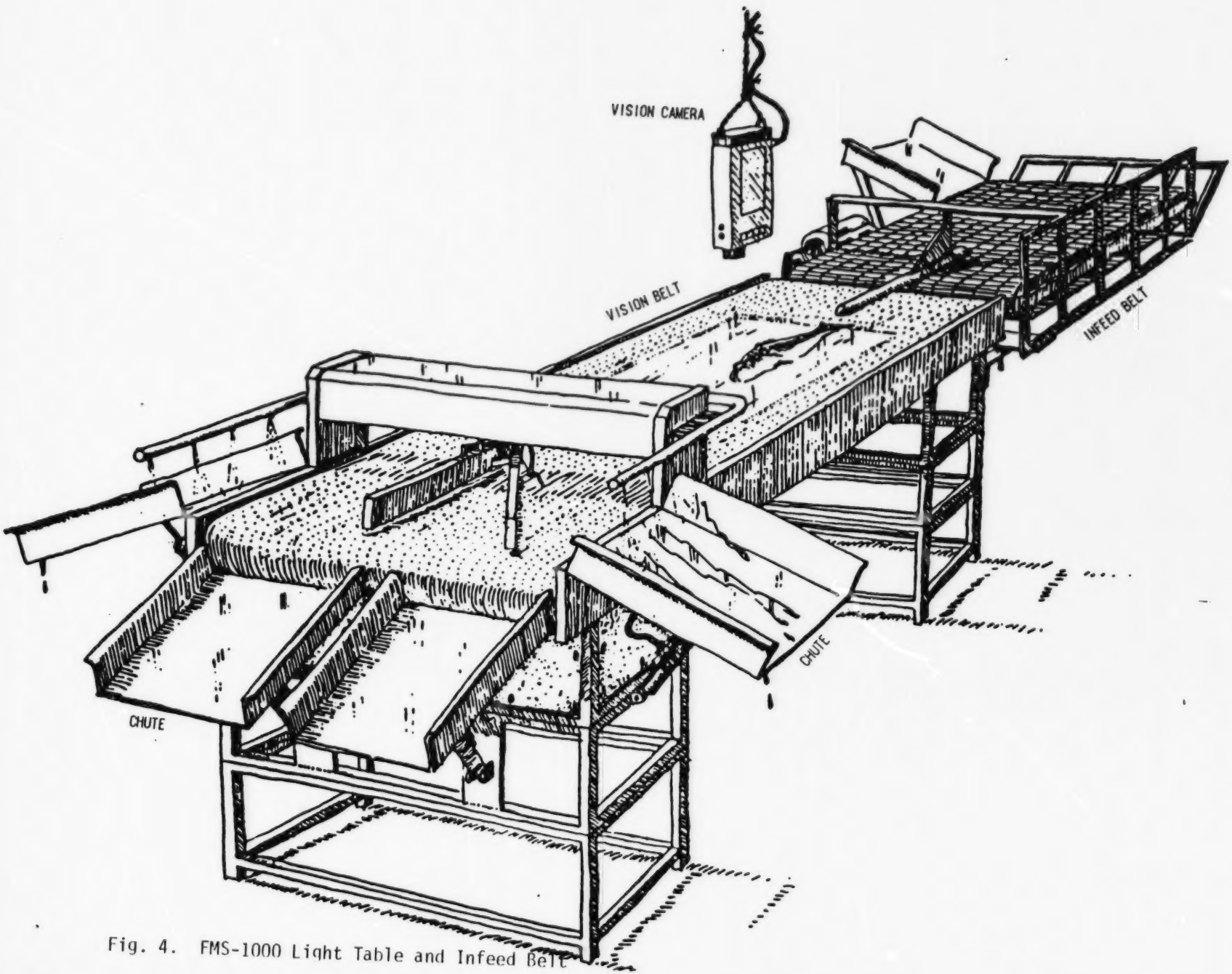
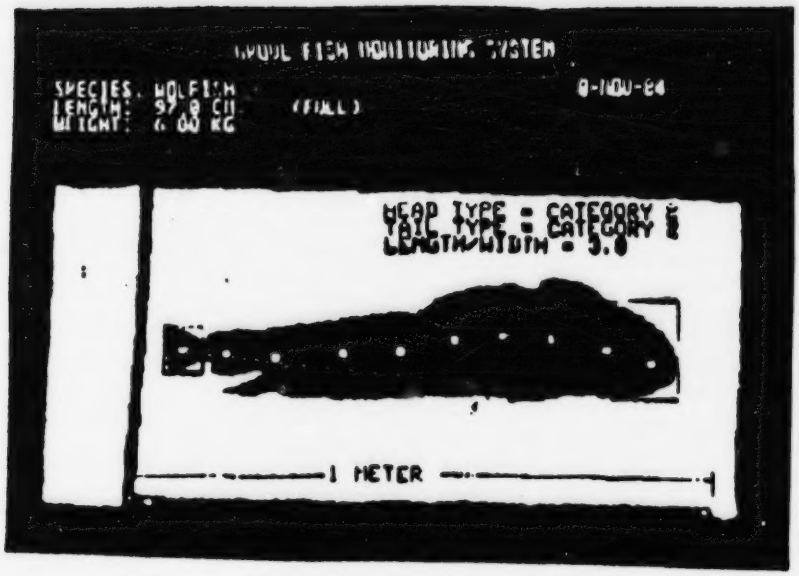


Fig. 4. FMS-1000 Light Table and Infeed Belt



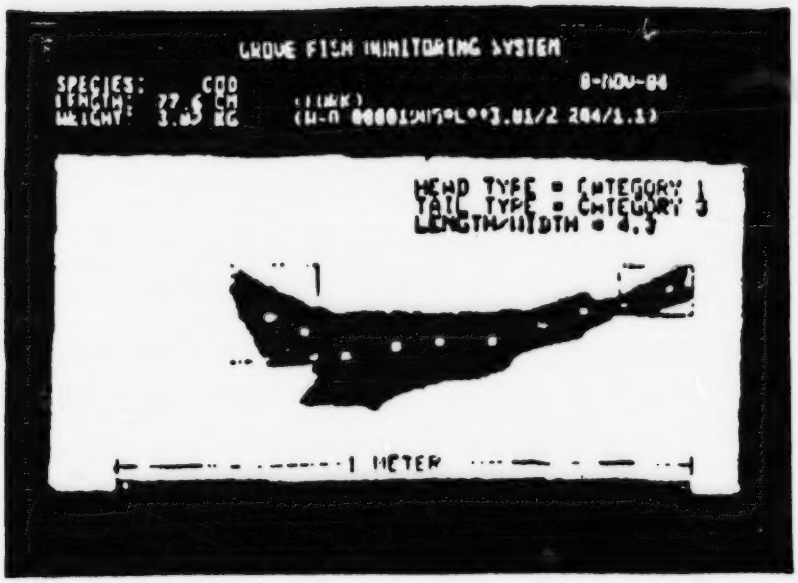


Fig. 5. Outline of Fish as Seen by the FMS-1000

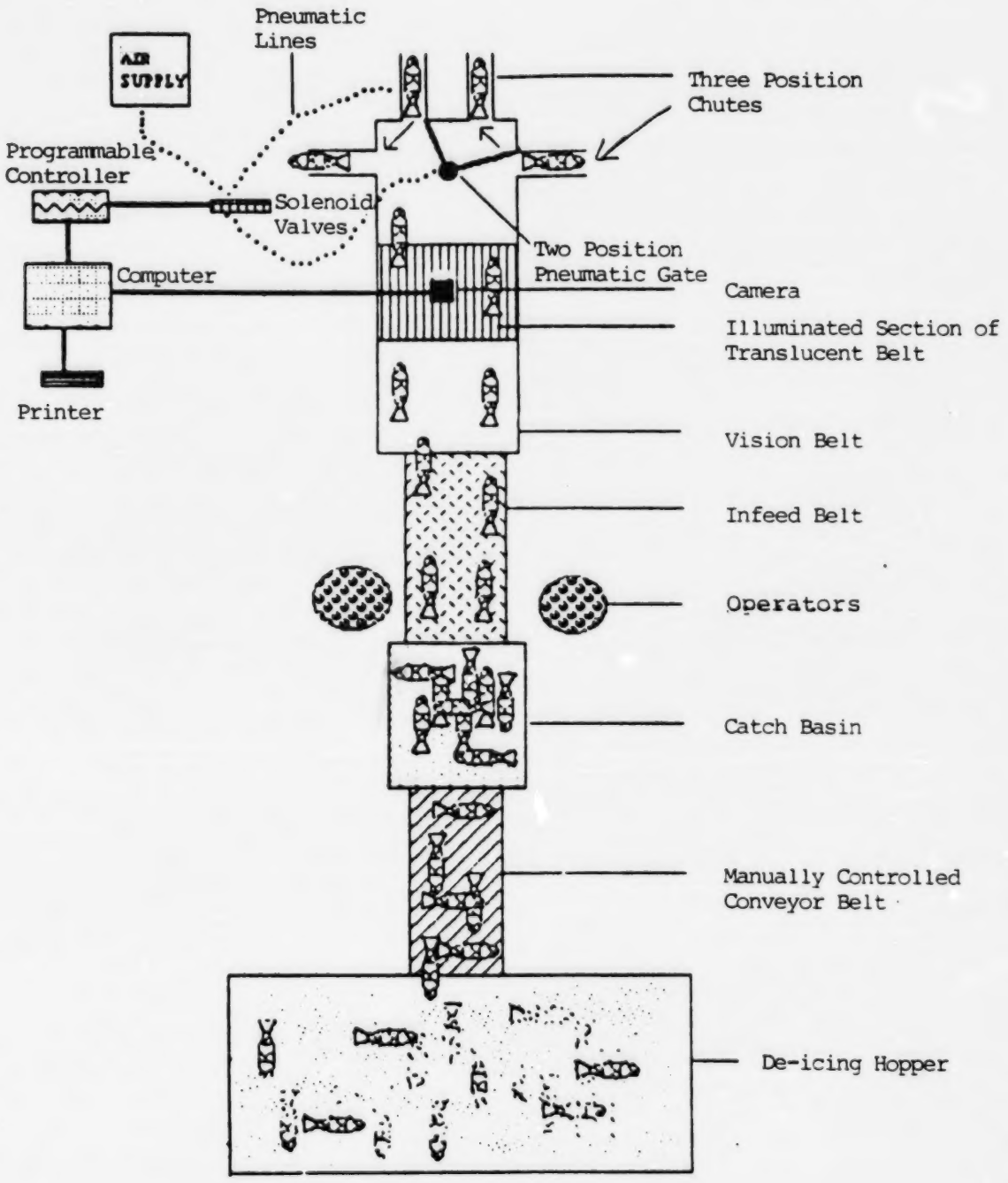


Fig. 6. Overall View of the FMS-1000

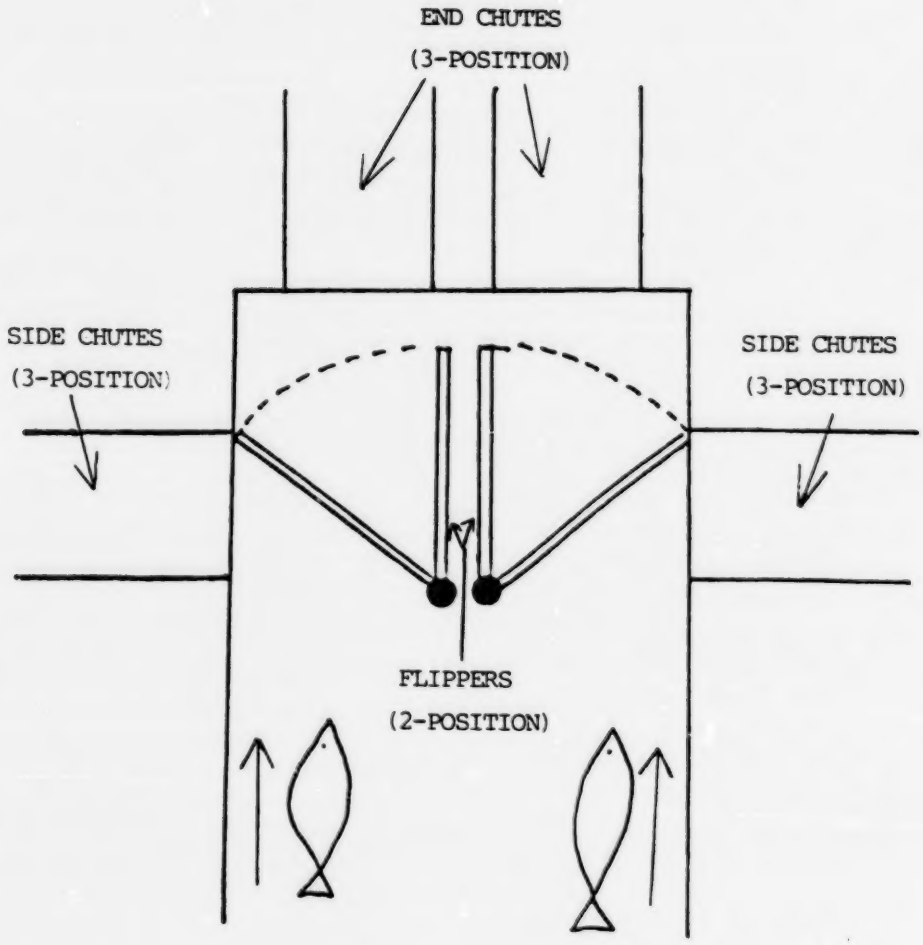


Fig. 7. Position Chute System

FMS 1000 EVALUATION FORM

Date : Sept 9, 1986 Sample No : 2 Technician : Kevin McCarthy

Inshore : ☐ Running Time : 2 hours, 10 mins.

Offshore : ☒ Down Time : Approx. 30-45 mins.

No.	Length Range	Specie	No. of Fish	FMS 1000 Weight	Actual Weight (lbs)
1.	E	COD	4693	9890.5	12,000
2.	F	COD	2704	6968,6	8,000
3.	G	COD	383	1610.4	NOT AVAILABLE
4.	H	COD	314	2286.8	NOT AVAILABLE
5.					
6.					
	Total:				

Length Frequency

No.	Length Range (Cod)						Length Range (Cod) Code
	E	F	G	H			
1.	18.0	21.5	26.0	27.75			Inshore
2.	17.75	24.75	28.0	30.75			A. < 18"
3.	20.25	23.5	24.5	37.5			B. 18" to 22.99"
4.	18.5	22.75	27.5	29.5			C. 23" to 28"
5.	19.5	22.75	25.5	30.0			D. > 28"
6.	17.75	21.25	24.75	32.0			Offshore
7.	18.5	25.25	27.5	32.78			E. < 20"
8.	20.0	24.0	28.0	30.25			F. 20" to 25"
9.	18.0	21.5	27.25	28.25			G. 25" to 28"
10.	20.0	20.0	28.0	32.0			H. > 28"

Remarks : Downtime due to overloading of the two Baader filleting machines and slow initial loading of de-icing hopper

NOTE: Seperate sheet to be used for each sample.

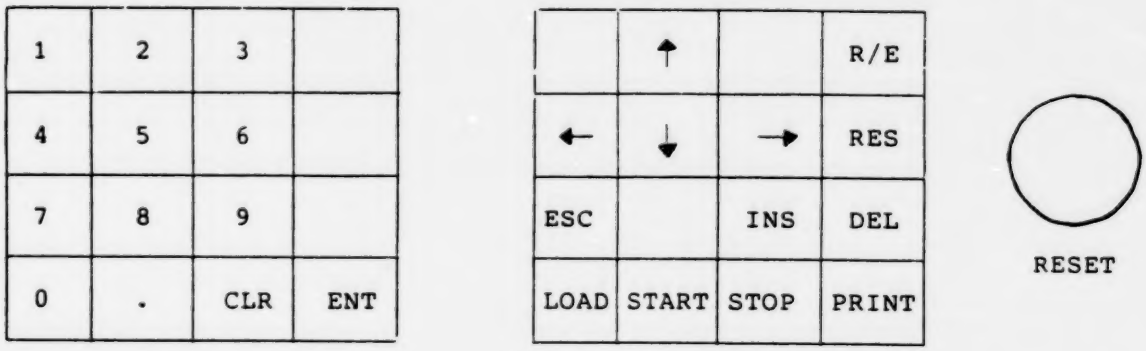
Fig. 8. FMS-1000 Evaluation Form

BS - Buffer Status
LS - Line Status
P - Chute Position

LMAX - Maximum Length
LMIN - Minimum Length

WMAX - Maximum Weight
WMIN - Minimum Weight

BS	LS	P	SPECIES	LMAX	LMIN	WMAX	WMIN
XX	XX	X	XXXXXXXXX	XXXX	XXXX	XXXX	XXXX



NUMERIC KEYPAD

FUNCTION KEYPAD

Function Keys:

R/E - RUN/EDIT changes the display from RUN buffer (parameters that the FMS is now using to sort fish) to EDIT buffer (new parameters) and vice versa. BS (buffer status) shows which buffer is currently displayed.

RES - RESTORE restores previous parameters.

ESC - ESCAPE cancels selected function.

INS - INSERT inserts new position or specie.

DEL - DELETE deletes present position or specie.

LOAD - sends contents of EDIT buffer (new sorting parameters) to the vision processor.

START - starts the sorting program.

STOP - stops the sorting program.

PRINT - prints report of fish analyzed by the FMS (see Figure 4)

Fig. 9. Recommended Operator's Control Panel